Year: 2013

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DOI: https://doi.org/10.1016/j.neuroimage.2013.01.020

Originally published at:
Tusche, Anita; Kahnt, Thorsten; Wisniewski, David; Haynes, John-Dylan (2013). Automatic processing of political preferences in the human brain. NeuroImage, 72:174-182.
DOI: https://doi.org/10.1016/j.neuroimage.2013.01.020

Automatic processing of political preferences in the human brain

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Abstract

Individual political preferences as expressed, for instance, in votes or donations are fundamental to democratic societies. However, the relevance of deliberative processing for political preferences has been highly debated, putting automatic processes in the focus of attention. Based on this notion, the present study tested whether brain responses reflect participants' preferences for politicians and their associated political parties in the absence of explicit deliberation and attention. Participants were instructed to perform a demanding visual fixation task while their brain responses were measured using fMRI. Occasionally, task-irrelevant images of German politicians from two major competing parties were presented in the background while the distraction task was continued. Subsequent to scanning, participants' political preferences for these politicians and their affiliated parties were obtained. Brain responses in distinct brain areas predicted automatic political preferences at the different levels of abstraction: activation in the ventral striatum was positively correlated with preference ranks for unattended politicians, whereas participants' preferences for the affiliated political parties were reflected in activity in the insula and the cingulate cortex. Using an additional donation task, we showed that the automatic preference-related processing in the brain extended to real-world behavior that involved actual financial loss to participants. Together, these findings indicate that brain responses triggered by unattended and task-irrelevant political images reflect individual political preferences at different levels of abstraction.

Keywords: political preferences, preference-based decision-making, donations, automatic valuation, fMRI

Introduction

In times of elections, huge budgets are spent on campaigns to inform political preferences and convince people to vote for particular candidates and their affiliated political parties. Recent findings indicate, however, that political preferences are by no means a prime exemplar for deliberate decisions but are considerably shaped by fast, automatic processes. Rapid judgments of competence based solely on the facial appearance of candidates were shown to reliably predict the outcome of elections (Todorov et al., 2005; Ballew and Todorov, 2007). Moreover, implicit measures of attitudes that assessautomatic evaluative associations(Greenwald et al., 1998) were found to improve the prediction of supposedly deliberate behavior such as political voting (Karpinski et al., 2005; Friese et al., 2007; Galdi et al., 2008). Furthermore, incidental exposure to environmental cues and irrelevant events has been suggested to shape political choices without participants' awareness (Bergeret al., 2007; Carteret al., 2011; Hassin et al., 2007; Healy et al., 2010).

Such automatic processing – guiding human judgments and choices in the absence of conscious deliberation – has previously been found to be reflected in brain responses for non-political stimuli. Neural activation has been shown to reflect preferences for paintings, houses and unknown faces when participants evaluated stimuli with respect to other, non-preference-related aspects (Kim et al., 2007; Lebreton et al., 2009). Activation patterns obtained in the absence of conscious deliberation were also reported to predict subsequent preferences for cars even when attention was diverted from potential choice options (Tusche et al., 2010).

Based on this evidence, we investigated whether brain responses track political preferences when political stimuli (i.e., images of national politicians) are presented to participants outside the focus of attention. We hypothesized that preferences for politicians might be encoded in brain areas such as the ventral striatum (VS), the medial prefrontal cortex (mPFC), the anterior cingulate cortex (ACC), and the insula that have previously been shown to be involved in automatic valuation and incidental processing of popularity of socially tagged stimuli (Kim et al., 2007; Lebreton et al., 2009; Mason et al., 2009, Tusche et al., 2010).Following up on findings that preferences for politicians can be predicted based on rapid inferences from viewing their faces, we assumed thatjudgments based on the visual appearance of political candidates might mediate these preference judgments (Todorov et al., 2005; Ballew and Todorov, 2007; Spezio et al., 2008; Antonakis and Dalgas, 2009). Given the human capacity of rapid face recognition and automatic retrieval of person knowledge (Gobbini and Haxby, 2007; Todorov et al., 2007), we further hypothesized that task-irrelevant images of prominent politicians might automatically activate mental representations of*affiliatedparties*. Hence, in a second step, we examined whether brain responses obtained during automatic processing of images of national politicians also reflect preferences for associated political parties. Taking advantage of the fact that preferences for a number of German politicians and for their affiliated political parties differ significantly, we used behavioral pretests to identify national politicians who were valued and appreciated, independent of participants' attitudes towards the associated parties. Likewise, we were able to determine several politicians who were consistently judged as rather unpopular — even if they belonged to the preferred political party (Figure 1A). This allowed us to select politicians such that participants' valuations of politicians were matched across parties and permitted us to disentangle preferences for associated parties from politician-specific processing.

Participants were instructed to perform a demanding visual fixation task while their brain responses were measured using fMRI. At unpredictable intervals, *task-irrelevant* images of politicians were passively presented in the background while the fixation task continued. Subsequent to scanning, participants' political preferences were measured both for passively viewed politicians and for affiliated parties. Importantly, during the acquisition of brain responses, participants were not aware that political preference judgments would be required later on. We then investigated whether brain responses reflect participants' preferences for the unattended politicians as well as for the associated political parties. Finally, we tested whether automatic preference-related processing in the brain extends to real-world behavior such as voluntary donations.

Materials and methods

Participants

Twenty healthy volunteers (aged between 22 and 33 years, 7 female) participated in the fMRI session and the behavioral posttest. Both sections of the experiment were approved by the local ethics committee. All participants were German native speakers, free of psychiatric or neurological history, had normal or corrected-to-normal vision, were right-handed and gave written informed consent. Participants were paid a fixed amount of €12 to take part in the study plus 20% of the remainder of an endowment of €12 that the participant did *not* donate to political parties after scanning. Data of one participant had to be excluded because of excessive head movement during scanning. Due to technical problems during the acquisition of functional images, data of another participant were incomplete and had to be discarded.

Stimuli

Monochrome images of 24 faces (front view with eye-gaze directed towards observer) were used as stimuli in the fMRI section of the experiment. All pictures were homogenized regarding size and contrast (MATLAB 7.0 and Adobe® Photoshop® CS2 9.0). During the fMRI experiment, images were centrally presented against a white background using MATLAB 7.0 in combination with the Cogent toolbox (http://www.vislab.ucl.ac.uk/Cogent).

Faces showed either familiar [F] or unfamiliar [UF] German politicians affiliated with one of two major competing parties represented in the federal government (Party A [P_A]: Christian Democratic Union, CDU; Party B [P_B]: Social Democratic Party, SPD). Unfamiliar politicians were included to obtain brain responses associated with automatic face processing of national politicians for which party-related information was lacking. Based on self-reported party preference (see below) obtained *after* scanning, one of the political parties [P_A/P_B] was defined as 'preferred' while the other one was specified as 'non-preferred' [P_{pref}/$P_{non\text{-}pref}$]. Each experimental condition ([F/P_{pref}], [F/$P_{non\text{-}pref}$], [UF/P_{pref}], [UF/$P_{non\text{-}pref}$]) was represented by 6 of 24 images of politicians that were chosen based on results from two behavioral pretests with independent samples. Pretest 1 (n = 20) was used to identify images of politicians who were highly familiar to participants ('Do you know this politician?') and whose party affiliation was well-known ('Which political party is this politician associated with?') using multiple-choice in a paper-and-pencil questionnaire. In pretest 2 (n = 30), a subsample of images of familiar politicians was presented together with a large number of images of politicians who were assumed to be unfamiliar. Self-reported familiarity with the politicians and with associated political parties confirmed the results of pretests 1 and established the correct assignment of unfamiliar politicians. Moreover, the results of a multiple-choice questionnaire of party affiliations showed that facial appearance of unfamiliar politicians did not allow identification of the associated political party above chance. Face-specific ratings obtained in pretest 2 also allowed selection of stimuli that were matched across experimental conditions with respect to judgments of facial attractiveness, trait inferences such as trustworthiness, competence, and threat, as well as valuation ratings for politicians (Figure 1A) (Winston et al., 2002; Todorov et al., 2005; Engell et al., 2007; O'Doherty et al., 2003; Spezio et al., 2008; van 't Wout and Sanfey, 2008). Please note that similar face-specific ratings were collected for participants subsequent to scanning to validate the results of the behavioral pretests. Images of the 24 politicians showed a neutral facial expression and were equated across experimental conditions with regard to sex, race and age.To ensure the coverage of a wide spectrum of valuation ratings for politicians, stimuli were selected such that within each experimental condition, some politicians were judged as negative while others were rated as positive. On average, valuation ratings for politicians were neutral for each condition. Importantly, while *politician*-specific judgments were found to be comparable across conditions (Figure 1A), findings from the pretests ensured that *party*-related valuations differed significantly. Thus, individual participants in both independent pretest groups showed a clear preference for one or the other political party. This allowed us to disentangle preference-related information concerning passively viewed politicians and associated political parties.

Tasks

Scanning Session. Participants in the event-related fMRI experiment were instructed to perform a demanding visual fixation task (Tusche et al., 2010). Every 0.8 s, a small, centrally presented black fixation square opened either to the left or to the right side (Figure 1C). Each time this occurred, participants had to respond with a corresponding left- or right-hand button press, using the index finger of the respective hand to operate a separate button box. At unpredictable intervals between 4.8 s and 9.6 s, task-irrelevant images of national politicians were shown in the background of the screen for 2.4 s while the fixation task continued. Prior to the fMRI session, participants were informed that these images only served the purpose of distracting them in the attention task and had to be ignored. Participants were asked to fixate on the task-relevant fixation square throughout the entire experiment and to maximize response accuracy. Within a run, each of the 24 images of national politicians was presented three times. Presentation order was pseudo-randomized, meaning that each politician was presented once in random order before it was repeated. Participants performed five runs consecutively, divided by a break of approximately one minute where no functional brain responses were acquired. It should be noted that during the acquisition of functional brain responses, participants were completely unaware of the necessity to subsequently make preference judgments. Participants' self-reports in the debriefing interviews after the experiment confirmed that this manipulation was successful.

Behavioral posttests. To test whether the paradigm had successfully diverted attention from politicians, approximately 10 min after scanning,participants completed a surprise memory test on 48 images of familiar and unfamiliar politicians affiliated with both political parties (24 presented during scanning, 24 novel images selected based on independent pretest data). In this self-paced computerized task, single images of politicians were presented to participants in random order. For each face, participants indicated via button press ('yes/no') whether this politician had been shown during scanning.

Next, self-report measures of participants' party preference were obtained using a paper-and-pencil questionnaire ('How much do you like party P_A/P_B?' rated on an 11-point Likert scale from -5 'strongly dislike' to +5 'strongly like'). Participants were, furthermore, given the opportunity to confidentially donate to political parties. In this computerized task, participants received an endowment of €12 and were informed that they could donate up to €6 to each of the political parties. Participants were also told that 20% of the money *not* donated would be added to the money they received for participating. Partial pay-out was implemented to provide a moderate incentive for donations. Participants were then asked if they were willing to donate to a particular party and for the exact amount of money indicated via button-presses. This procedure was then repeated for the other party. Presentation order of political parties was counterbalanced across participants. We also assessed implicit measures of party preference using an Implicit Association Test (IAT; Greenwald et al., 2003; Supplementary Table 1). Given compelling meta-analytical evidence (Greenwald et al., 2009) of high correspondence of self-reports and implicit measures in the domain of political preferences, the main purpose of this implicit measure was to validate participants' self-reports and to assess party preferences of participantswho might explicitly state to be indifferent.

Finally, participants' political preferences were collected for the politicians who were presented during the fMRI session. Individual preference rank orders ranged from 1 ('least preferred politician') to 24 ('most preferred politician'). In addition, we obtained politician-specific ratings, including judgments on likeability, attractiveness, and trait inferences (Likert scales ranging from -5 to +5) as well as familiarity judgments ('Known prior to scanning?', Yes/No) to confirm results of the independent pretests. A linear mixed model approach, as implemented in SPSS 19, was used to address the relationship of face-specific judgments with preference ranks for politicians. Prior to each step of the post-scanning data collection of political preferences, participants were given the opportunity to refuse to provide information or withdraw their data at any time. Subsequent to the behavioral post-tests, participants were debriefed and paid.

Functional image acquisition

Functional MRI data were collected using a 3-Tesla whole-body scanner (Siemens TRIO) with a standard head coil. T2*-weighted functional images were obtained using an echoplanar imaging (EPI) sequence (repetition time = 2.4 s, echo time = 30 ms). For each of the five runs, 291 sequential EPI volumes were collected (36 ascending axial slices per volume, slice thickness 2 mm, in-plane resolution 3mm × 3mm, 1 mm interslice gap, matrix size 64 × 64).

Data analysis

Functional images were analyzed using the statistical parametric mapping software SPM8 (http://www.fil.ion.ucl.ac.uk/spm) implemented in Matlab. For each data set, the first two volumes were discarded to allow for equilibration effects. Brain volumes were temporally corrected for slice timing and were spatially realigned to the first functional image. Functional data were then spatially normalized to the standard MNI space (Montreal Neurological Institute) and smoothed using a Gaussian kernel with a full-width at half-maximum (FWHM) of 8 mm. Preprocessed data were analyzed using a general linear model (GLM) as implemented in SPM8 (Friston et al., 1995). For every run, the conditions of interest were modeled by distinct regressors convolved with a canonic hemodynamic response function (hrf). Individual movement parameters were used as regressors of no interest. A 128 s high-pass cutoff filter was applied to eliminate low-frequency drifts in the data. For each participant, we estimated multiple GLMs.

Preference for passively presented politicians

In the first GLM, we made use of the continuous information on participants' preference rank orders for politicians obtained after scanning. For each participant, functional data of familiar politicians (illustrated in blue in Figure 1B) and unfamiliar politicians (illustrated in yellow in Figure 1B) were modeled individually by one regressor and one parametric regressor reflecting preference ranks of 1 to 12 for these politicians. For each participant, we computed contrasts for parametric regressors of familiar politicians and entered them into a random effects group analysis using a one-sample t-test (family-wise error (FWE) corrected at cluster-level at $p < 0.01$, height threshold of $p < 0.001$, $k > 10$ voxels). This statistical threshold was used for all analyses of interest and will be referred to as $p < 0.01$ (FWEcluster corrected) throughout the manuscript. An identical analysis was performed for parametric regressors of *unfamiliar* politicians. In an additional control analysis at the group level, both parametric regressors were *jointly* entered into a random effects group analysis using a repeated measure ANOVA to contrast familiar and unfamiliar conditions against each other (blue vs. yellow as illustrated in Figure 1B). Unless stated otherwise, *control* analyses were performed at a more liberal statistical threshold of $p < 0.001$, uncorrected for multiple comparisons, with an extent cluster threshold of $k > 10$ voxels.

Preference for associated political parties

In a second GLM, we created four regressors of interest for each of the five runs: F/P_A, UF/P_A, F/P_B, and UF/P_B. Based on measures of self-reported party preference obtained *after* scanning, one of the political parties [P_A/P_B] was defined as 'preferred' while the other one was specified as 'non-preferred' [$P_{pref}/P_{non-pref}$]. For every participant, parameter estimates of all conditions were used in a random effects group analysis using an ANOVA with repeated measures. Parameter estimates for *familiar* politicians of the preferred [F/P_{pref}] and of the non-preferred political party [$F/P_{non-pref}$] were contrasted against each other ($p < 0.01$, FWE cluster corrected; bright blue minus dark blue as illustrated in Figure 1B). Identical contrasts were implemented for parameter estimates of the control condition of *unfamiliar* politicians [UF/P_{pref} vs. $UF/P_{non-pref}$] (bright yellow vs. dark yellow as illustrated in Figure 1B). Given that these stimuli lacked information on associated parties, brain responses for unfamiliar politicians were not assumed to differ for the preferred and the non-preferred party. Both contrasts of this control analysis were performed at $p < 0.001$, uncorrected, k >10 voxels.

Donations. Brain regions that were more activated in the contrast [F/P_{pref} minus $F/P_{non-pref}$] described above – for passive viewing of familiar politicians associated with the preferred vs. the non-preferred party – were defined as regions of interest (ROIs). We then examined whether activation in these ROIs reflectedindividual differences in voluntary donations to political parties subsequent to scanning. This analysis enabled us to investigate whether brain responses in these areas reflected*actual preference-based behavior* that involves financial loss to the participant. Moreover, it allowed us to test if neural responses in these regions varied *linearly* with differences in voluntary donations to political parties.It should be noted, however, that donations and self-report assessments of party preference were not fully independent. For each ROI, we extracted brain responses of participants' party-specific contrasts for the familiar condition [F/P_B minus F/P_A]. We then estimated the average activation across all voxels of a ROI and correlated it with differences in voluntary donations to parties [€(P_B) minus €(P_A)]. Please note that conditions were specified by *party affiliation* [P_A vs. P_B], independent of participants' self-reported party preference. This analysis was also performed for the control condition of unfamiliar politicians

[UF/$P_B$minus UF/P_A]. We applied Bonferroni correction to ROI-based analyses to control for multiple comparisons.

Results

Behavioral Results

*Party preference.*Self-reportedparty preference (Likert scale of -5 to +5) was determined by subtracting individual liking ratings for P_A(Mean ± SD: -1.56 ± 3.05, range of -5 to +4) from those for P_B(1.11 ± 1.81, range of -3 to +4; at $p < 0.05$, two tailed paired t-test).Positive values of the preference score (2.67 ± 4.00, range of -4 to +9) indicated that P_B was favored over P_A. Implicit measures of party preference (D scores of IAT, Greenwald et al., 2003) confirmed these self-report assessments for all but one participant, who explicitly reported to be indifferent but showed an implicit preference for P_B (Pearson's $r = 0.72$, $p \leq 0.001$; Supplementary Figure 1A). For this participant, the implicit preference score was used to define the preferred and the non-preferred party for subsequent analyses. Given the close match of both measures (and comparable results when using D scores), the results section will focus on self-reported data (see Supplementary Figure 1A-D for overview of results using D scores).

*Donations.*All but one participant decided to donate to the political parties (up to €12, maximum of €6 per party), with average contribution of €3.68 (± €2.32 SD). As expected, donations were found to be significantly higher for the preferred party (€3.17 ± €2.04) than for the non-preferred party (€0.51 ± €0.99) (two tailed paired t-test, $p < 0.001$). As with the self-report assessments, participants'donation preference scores were estimated by subtracting voluntary donations to P_A (€1.21 ± €2.06, range: €0 to €6) from donations to P_B (€2.47 ± €1.95, range: €0 to €6).Participants' difference scores of donationsranged from-6 to 6 (1.26 ± 3.27)andwere found to be positively correlated with measures of self-reported party preference (Pearson's $r = 0.73$, $p < 0.001$) (see Supplementary Figure 1B for illustration of correlation with D scores). Both self-report measures and donation behavior pointed to a slight bias in favor of P_B. Yetindividual preference strengths for P_B over P_A varied considerably across participants (Δ self-reported party preference: range of 0 to9, SD = 2.41; Δ donations: range of €0 to €6, SD = €2.17).

Control variables. Confirming the results from the independent pretests, likeability ratings for the politicians were found to be comparable across experimental conditions (2 × 2 repeated measures ANOVA; main effect 'party': $F(3,51) = 1.38$, $p = 0.26$; main effect 'familiarity': $F(3,51) = 0.02$, $p = 0.90$; interaction term: $F(3,51) = 1.20$, $p = 0.29$). Likewise, judgments on facial attractiveness and trait inferences such as trustworthiness, competence and threat were shown to be balanced for familiar and unfamiliarpoliticians of the preferred and non-preferred party (all $p > 0.05$ for main and interaction terms).We used a linear mixed model approach to address the relationship of these face-specific judgments with preference ranks for politicians. We treated familiarity of faces as a fixed factor, using politician-specific ratings as covariates, while subjects were defined as random factors. We found that judgments of trustworthiness, competence and likeability were significant predictors of preference ranks of politicians (all $p < 0.005$). Importantly, none of the interaction terms of politician-specific judgments were significant with familiarity (all $p > 0.14$), indicating that perceived trustworthiness, competence and likability are potentially important predictors of preferences for both familiar and unfamiliar politicians. Supplementary analyses on the relationship of these ratings with activation in the VS and on their mediating role for the relationship of VS activity with preference ranks of politicians are available in the supplementary material. In line with results of the independent pretests, 97% of the 'familiar' politicians were reported as familiar to the participants prior to scanning, while 93% of the 'unfamiliar' politicians were rated as unknown.

Attention modulation. Average recognition rates [d' = z(hits) - z(false alarms)] for 48 images of familiar and unfamiliar politicians affiliated with both political parties(24 presented during scanning, 24 novel) were found to be close to 0 (± 1.6 SD). Moreover, a secondary analysis onrecognition rates showed that there were no differences for familiar politicians of the preferred and the non-preferred party (two tailed paired t-test, $p > 0.17$). This indicates that a successful encoding of party preference for passively viewed familiar politicians is unlikely to be due to differential attention to facial stimuli affiliated with either party. Furthermore, results of an inattentional blindness experiment we conducted (following Mack and Rock, 1998) using an independent sample indicated that the fixation task effectively prevented participants from actively deliberating about the politicians and their associated political parties. In this behavioral experiment outside the scanner, 20 participants were instructed to perform exactly the same task as participants in the scanner. After approximately 11 minutes, the task was abortedduring the presentation ofan image of a politician that was followed by the presentation of arandom visual noise pattern. Participants were immediately asked to identify the face of the last politician presented as well as the associated political party by selecting one of the presented options. The number of hitswasnot different from chance both for the politicians (Chi-Square $(1,20) = 1.71$, $p = 0.19$) andthe associated party (Chi-Square$(1,20) = 1.80$, $p = 0.18$).Moreover, 19 of 20 participants reported that their choices were based on guessing. Results of a paper-and-pencil-questionnaire showed that all participants were familiar with the lastpolitician presented and his/her party affiliation.

FMRI Results

The present paradigm allowed us to investigate participants' preferences both for passively presented politicians as well as for their affiliated political parties.

Preference for passively presented politicians

Preference ranks for *familiar* politiciansobtained after scanning correlated with trial-wise BOLD responses in the bilateral ventral striatum (VS) ($p < 0.01$, FWE cluster corrected). See Table 1 for a complete list of results and Figure 2A for an illustration (for results at a more lenient statistical threshold of $p < 0.001$, uncorrected for multiple comparisons, $k > 10$voxels, see Supplementary Table 2). Interestingly, activation in the VS reflected preference ranks for familiar politicians from both the preferred and the non-preferred party (peak at [MNI 6, 8, 13]; $p < 0.01$, FWE cluster corrected, Supplementary Table 3). Moreover, average parametric responses in the VS were comparably high for familiar politicians of the preferred and the non-preferred party (two tailed paired t-test, $p = 0.35$; Figure 2C).

Striatal activity was also correlated with preference ranks for the control condition of *unfamiliar* politicians(peak at [MNI 6, 8, 10]; $p < 0.01$, FWE cluster corrected; Figure 2B).Moreover, activation in the bilateral fusiform gyrus ([MNI 30, -49, -11] and [MNI -36, -49, -17]), midbrain [MNI 3, -31, -5] and supplemental motor area ([MNI -15, -7, 73] and [MNI 15, -10, 67]) were found to reflect preference ranks for unfamiliar politicians at this statistical threshold (Supplementary Table 4). No brain region was significantly more stronglycorrelated with preference judgments for familiar than for unfamiliar politicians or vice versa ($p < 0.001$, uncorrected, $k > 10$ voxels).

Preference for associated political parties

Party preference. Based on self-reported party preference, we then contrasted brain responses obtained during passive viewing of *familiar* politicians affiliated with the *preferred party* minus those affiliated with the *non-preferred party*[F/P_{pref} minus $F/P_{non\text{-}pref}$]. Please note that our selection of politicians ensured that politicians were equally popular in both parties. Increased activation for politicians of the preferred party minus politicians of the non-preferred party was found in the bilateral anterior insula, the superior temporal gyrus and the cingulate cortex ($p < 0.01$, FWE cluster corrected). The latter cluster comprised the posterior cingulate cortex (PCC) and the anterior cingulate cortex (ACC)extendinginto the medial cortex (mPFC). See Table 2 for details and Figure 3A for illustration of the results (Supplementary Table 5 displays results obtained at a more lenient threshold of $p < 0.001$, uncorrected, $k > 10$voxels). No brain region was found to be significantly more activated in the reverse contrast [$F/P_{non\text{-}pref}$ minus F/P_{pref}]($p < 0.001$, uncorrected, $k > 10$ voxels). Identical contrasts for the control condition of *unfamiliar* politicians [UF/P_{pref}vs.$UF/P_{non\text{-}pref}$] – with no information on associatedpolitical parties available – did not yield significant results($p < 0.001$, uncorrected, $k > 10$ voxels).

Please note that politicians affiliated with a particular party were selected such that valuation judgments for politicians were matched across parties, allowing preferences for associated political parties to be disentangled from politician-specific processing. To provide further evidence that brain responses in the insula and the cingulate cortex do not merely reflect differential liking for politicians,we implemented an independent GLM that contained parametric regressors for self-reported party preference that were orthogonalized with respect topolitician-specific valuation ratings (using standard serial orthogonalization of parametric regressors within an experimental condition as implemented in SPM8).Group analysis (simple t-test) on individual parametric regressors for party preference confirmed that activation in the cingulate cortex and the insula encoded party preference independent of politician-specific valuation (Figure 4).

Donations. In a further step,we examined whether activation in the cingulate cortex and the insula (see above)reflectedindividual differences in *actual preference-based behavior* concerning the parties (i.e., donations). See Table 2 for details on the clusters in the cingulate cortex and the insula that were used as regions of interest (ROIs). To address this issue, average activations(across voxels) in these regions were extracted from the individuals' *party-specific* contrasts [F/P_B minus F/P_A] and correlated with *party-specific*difference scores of donations [€P_B minus €P_A]. Across participants, donationswere positively correlated with activation in the bilateral insula (Pearson's r = 0.63, $p < 0.05$) (Figure 3B) and in thecingulate cortex,respectively(Pearson's r = 0.51, p <0.05, one tailed) (Figure 3C).Reported p-values for ROI-based analyses are Bonferroni corrected for multiple comparisons. Identical analyses for brain responses obtained in the control condition of unfamiliarpoliticians[UF/P_B minus UF/P_A] did not yield significant results (all $p > 0.72$, uncorrected). Please note that brain responses in the VS that reflected preference ranks for politicians were not correlated with donations to the affiliated parties (Pearson's r = 0.10, p = 0.69, uncorrected; Figure 2D).

Discussion

Research has begun to investigate neural activation that underlies the processing of political attitudes and preferences (Amodio et al., 2007; Zamboni et al., 2009), including studies on *deliberative* processing of political statements and simulated voting for political candidates (Westen et al., 2006; Spezio et al., 2008; Gozzi et al., 2010; Bruneau and Saxe, 2010; Rule et al., 2010).Yet the neural substrate underlying automatic processing of political preferences (Todorov et al., 2005; Ballew and Todorov, 2007; Berger et al., 2008; Galdi et al., 2008; Hassin et al., 2007; Carter et al., 2011; Healy et al., 2010) remains largely unstudied. Extending earlier fMRI studies, the present studyshowed that brain responses can reflect individual political preferences – for politicians and associated parties – in the *absence* of conscious deliberation and attention.

Participants' preference ranks for national*politicians* that were obtained after scanning were reflected in the ventral striatum (VS), a region frequently involved in reward processing, valuation and social influence of stimulus value (Montague and Berns, 2002; Schultz, 2000; Kable and Glimcher, 2007, Campbell-Meiklejohn et al., 2010). In line with this finding, activation in the VS has previously been shown to reflect preference judgment for various objects when participants actively evaluated these stimuli with respect to other, non-preference-related aspects such as roundness or age (Kim et al., 2007;

Lebreton et al., 2009; Levy et al., 2011). Extending these earlier findings, the present study predicted individual preference ranks for *task-irrelevant* politicians from striatal activation while attention was diverted to an unrelated, ongoing task. Evidence for the successful removal of attention was provided by results of a subsequent memory test for images of politicians immediately after scanning. Moreover, in an inattentional blindness experiment (following Mack and Rock, 1998) using an independent sample, participants performed at chance level when the distraction task was suddenly terminated and they were asked to select the last politician presented. These findings strongly suggest that attention was effectively attenuated by the distraction task. Interestingly, neural responses in the VS were found to correlate with subsequent preference judgments for politicians independent of participants' party preference. Thus, striatal activation related to preference ranks was comparable for familiar politicians affiliated with the preferred and the non-preferred party. This was confirmed in a supplementary analysis that parametrically employed preference ranks for familiar politicians from both parties separately. These results indicate that fast, automatic valuation processes in the striatum are presumably based on the facial appearance of *individual* political candidates rather than on abstract categorical information such as party affiliation. This notion is consistent with previous studies showing that political preferences such as votes for political candidates can be predicted based on rapid inferences from faces (Todorov et al., 2005; Ballew and Todorov, 2007; Antonakis and Dalgas, 2009). Further support for this interpretation is provided by our finding that brain activity in the VS reflected preference ranks for unfamiliar politicians with no prior knowledge of the politician available.Results of a supplementary analysis indicate that perceived competence, trustworthiness and likability of the faces might mediate the preference judgments for politicians, independent of their familiarity.

Note that we selected politicians such that valuation judgments of politicians were matched across the affiliated political parties. Thus, independent behavioral pretests were used to identify familiar politicians who were well-liked, independent of the political party that they belonged to. Likewise, we used pretests to determine familiar politicians who were rather unpopular, even though they were associated with a subject's preferred political party.This allowed us to disentangle preferences for associated parties from politician-specific processing. Confirming results of independent pretests, participants' evaluation of politicians was found to be comparable across parties while liking judgments for the associated parties differed significantly. Hence, in a next step, we tested whether brain responses – obtained in the absence of conscious deliberation and attention to task-irrelevant politicians – reflect participants' political preferences for *parties*. We found that activation in the bilateral insula and the cingulate cortex (extending to the mPFC) increased significantly during presentation of politicians associated with the preferred compared to those associated with the non-preferred party. Further support for this finding was provided by an additional analysis with a parametric regressor for party preference that was orthogonal to individual valuation judgments of politicians. Group analyses revealed that activation in the insula and the cingulate cortex parametrically encoded participants' party preference *independent* of politician-related evaluation. These findings strongly suggest that the neural encoding of party preference was not merely due to slight variations in valuation judgments for politicians but rather related to automatic preference-related processing at a higher level of abstraction (i.e., affiliated political parties). Thus, the present findings suggest that brain responses triggered by task-irrelevant images of national politicians might be used to reliably encode individual preferences for associated parties.

Brain regions that reflected participants' party preferences have been previously implicated in making preference decisions when participants actively deliberated about the choice at hand (Paulus and Frank, 2003; Kim et al., 2007; Kang et al., 2011). Thus, increased activation in the insula, mPFC and the adjacent ACC was found for preference judgments for consumer items (Paulus and Frank, 2003) and for faces (Kim et al., 2007). In line with recent findings that linked activation in the insula to value signals (Kahnt and Tobler, in press) and decision values (Kang et al., 2011), the bilateral insula, the mPFC, and the ACC were also found to be positively correlated with self-reported preference judgments for consumer products (Knutson et al., 2007). Note, however, that empirical evidence has also linked deactivation of the right insula with preference-based consumer choices in a purchase task (Knutson et al., 2007). Changes of preferences were also found to be positively correlated with activation in the anterior insula and the dorsal ACC when participants made explicit preference judgments for songs (Berns et al., 2010).Moreover, activation in these brain regions has been involved in *automatic* valuation and preference judgments. Brain responses in the PCC and the mPFC were shown to be significantly higher for preferred stimuli compared to non-preferred stimuli even when such judgments were not required (i.e., passive viewing) or when age judgments were performed (Lebreton et al., 2009; Levy et al., 2011). Activation patterns in the mPFC and the bilateral insula, encompassing the ACC, were also found to predict real-world preferences such as the willingness to buy a car when attention was diverted from the products (Tusche et al., 2010). Moreover, activity in the insula was shown to increase when performing a categorization task on familiar politicians congruent with participants' political attitudes compared to attitude-incongruent conditions (Knutson et al., 2006). The present study significantly extends these earlier findings on automatic valuation in the brain by examining processing of political preferences at different levels of abstraction. Thus, brain responses in the VS were found to be associated with preferences for task-irrelevant *politicians*, while activation in the insula and the cingulate cortex reflect individual preferences for the associated political *parties*.

Following up on evidence that activity in the anterior insula and the mPFC predict complex, real-world behavior such as consumer choices or health-related behaviors (Tusche et al., 2010, Falk et al., 2010, Falk et al., 2011), we tested whether brain responses could be linked to actual participants' preference-based behavior. Neural responses in the insula and the cingulate cortex (encompassing the mPFC) that reflected self-reported party preferences were found to linearly vary with donations to political parties after scanning. In line with the present results, brain responses in these regions were recently implicated in making deliberate donation decisions. The ACC (BA 24/32) was shown to be more active when making donations to others compared to decisions relating to a monetary reward for oneself (Moll et al., 2006). Increased activation in the ACC, PCC, mPFC and insula was also found when participants made free donation choices compared to executing predefined donations (Hare et al., 2010). Supporting our findings, the authors showed that activity in the mPFC (BA 10) encompassing the ACC (BA 32) obtained during voluntary donations varies linearly with the amount of money donated. Based on functional connectivity measures, the authors suggested that the mPFC, which encoded donations, might integrate signals from the cingulate cortex (BA 24, 32) and the bilateral insula (Hare et al., 2010). However, the present data suggest that neural activation in each of these brain areas individually reflects subsequent voluntary donations. Moreover, adding to earlier studies on deliberative donation decisions, the present findings suggest that donations are reflected in the brain even when no choices are required.

One interpretation of the present findings is that the VS may be particularly relevant to automatic valuation and preference processing of appearance-related aspects of environmental stimuli, including images of politicians. Moreover, the finding that the VS also reflected preferences for *unfamiliar* politicians suggests that neural processes in this area might play a role in initial preference formation. This interpretation is consistent with previous findings on face preference decisions (Kim et al., 2007). Brain regions such as the mPFC, the cingulate cortex or the insula, on the other hand, might be involved in a brain network that processes associative knowledge concerning prominent politicians, including associations that underlie attitudes towards political parties. Thus, the present findings suggest that distinct neural structures in the brain might engage in stimulus-specific valuation for passively presented images of politicians and in processing of associative knowledge including attitudes towards affiliated parties.

Taken together, the present findings indicate that the brain automatically engages in assessing individual political preferences, both for unattended politicians as well as for associated political parties. This was found to hold true for brain regions that have previously been reported to underlie automatic valuation and preferences. Importantly, distinct brain regions were found to encode preferences at different levels of abstraction: preferences for images of *individualpoliticians* were reflected in activation in the VS, whereas preferences for the *associated political parties* were reflected in activity in the insula and the cingulate cortex. Brain responses in the insula and the cingulate cortex even predicted subsequent donations to political parties, showing that automatic preference-related processing extends into behavior that involves actual financial loss to participants. These findings support the notion that brain responses obtained in choice-free settings reflect complex future choices at different levels of abstraction, long before any conscious deliberation.

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Appendices

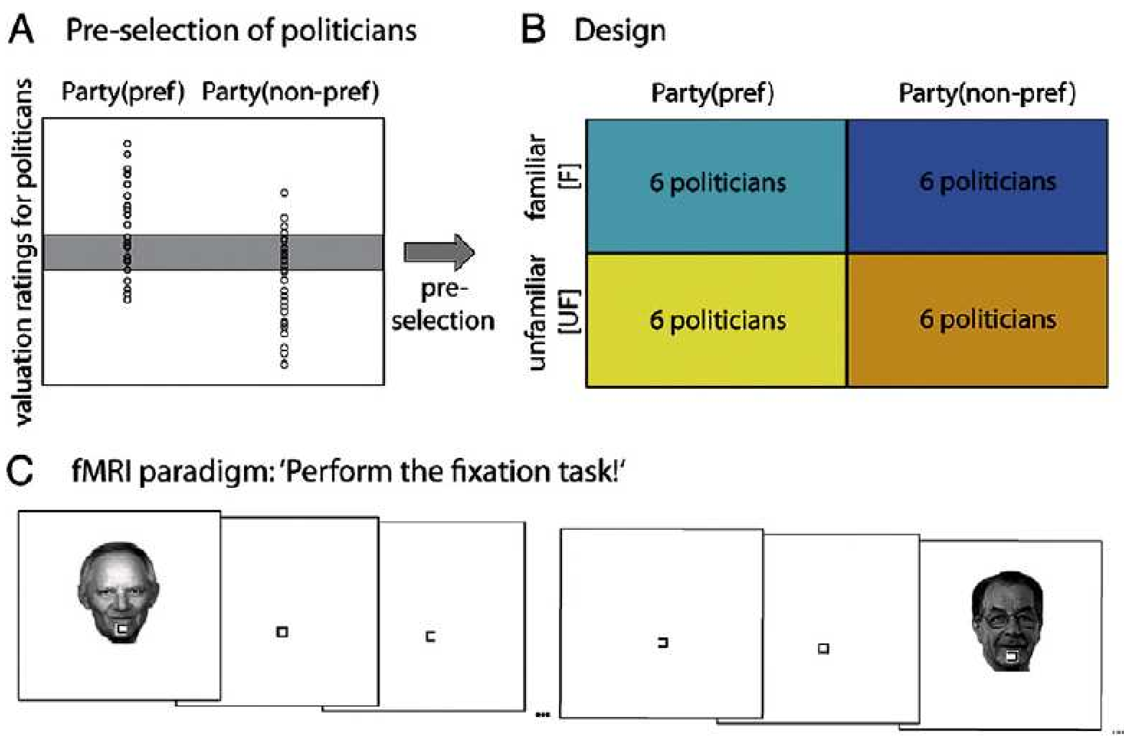

Figure 1. Experimental design and task.

A. Illustration of the pre-selection of politicians to disentangle preferences for politicians and associated political parties: Images of national politicians were chosen based on results from behavioral pretests using independent samples. Politicians were selected such that politician-specific valuation judgments were matched across the preferred and the non-preferred party (illustrated by the gray bar). **B.** Design: Images showed faces of either familiar [F] or unfamiliar [UF] national politicians affiliated with one of two major competing national parties [P_A/ P_B]. Based on ratings of self-reported party liking, parties were defined as either preferred [P_{pref}] or non-preferred [$P_{non\text{-}pref}$]. **C.**fMRI task: Participants performed a demanding visual fixation task that diverted attention from politically-relevant stimuli (i.e., images of national politicians) that were projected onto the background of the screen at unpredictable intervals while the fixation task continued.

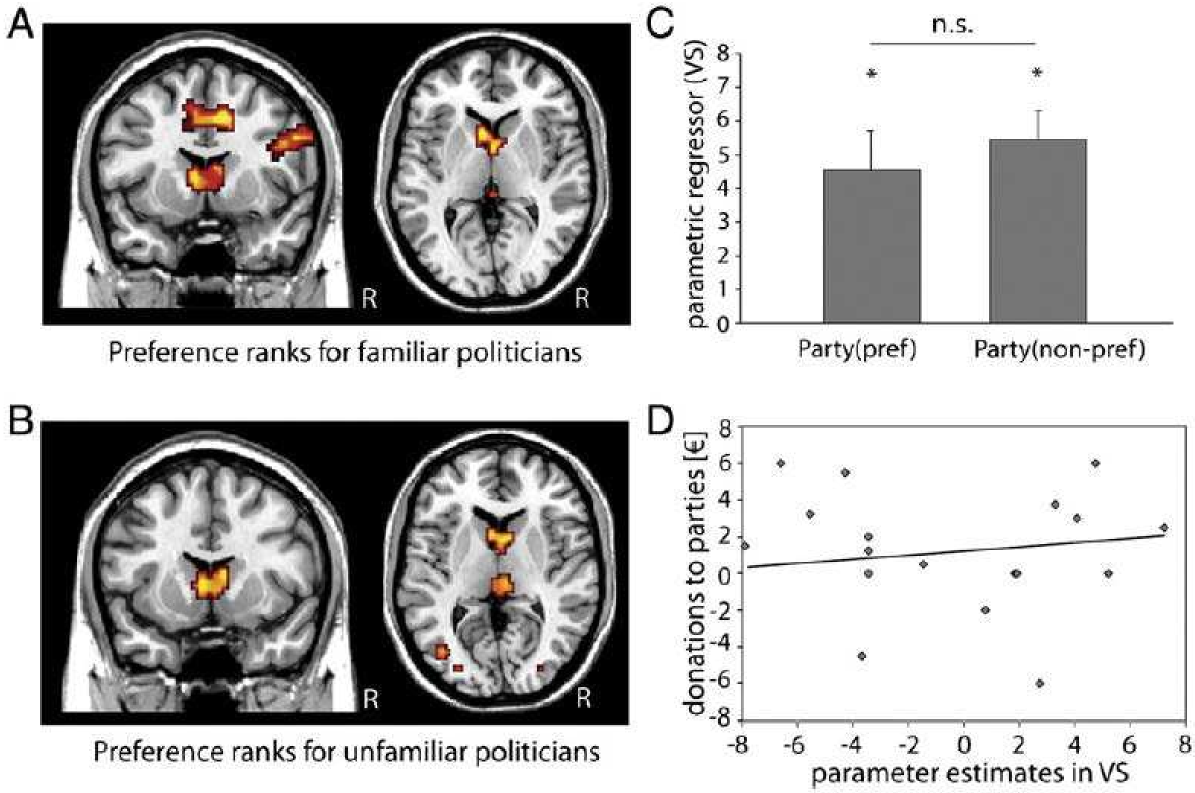

Figure 2. Neural encoding of preference ranks for *politicians*.

A. Activation in the bilateral VS was found to correlate with participants' preference ranks for task-irrelevant *familiar* politicians in a parametric manner. Contrasts are shown at p < 0.01, FWE cluster corrected. R indicates the right hemisphere. **B.** The bilateral VS was also positively correlated with preference ranks for task-irrelevant *unfamiliar* politicians at p < 0.01, FWE cluster corrected. **C.**The graph displays average parametric responses in the VS for familiar politicians of the preferred and the non-preferred political party that were found to be comparably high (two tailed paired t-test, p = 0.35; bars indicate standard errors).**D.** Activation in the VS that parametrically encoded preference for politicians did not reflect *party* preference as measured by donations to parties (Pearson's r = 0.10, p = 0.69).

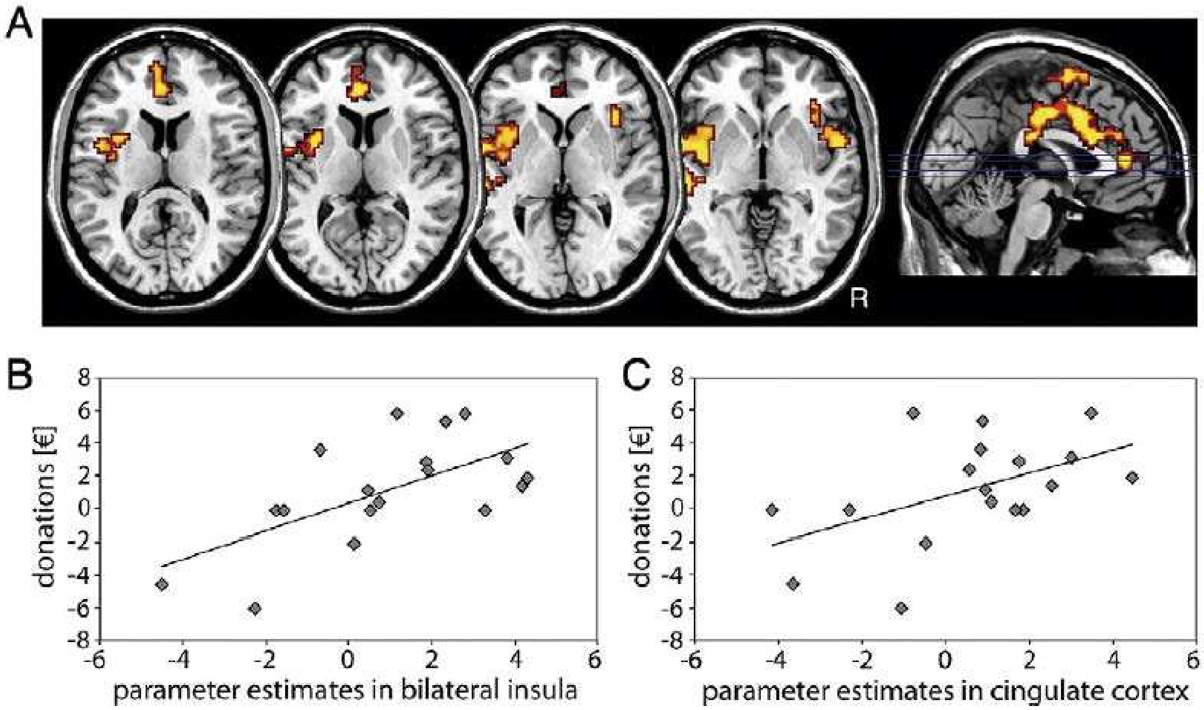

Figure 3. Brain regions that automatically encoded *party* preference.

A. Brain responses in the bilateral insula and the cingulate cortex (extending to the mPFC) were significantly more activated during passive viewing of familiar politicians associated with the preferred than with the non-preferred party [F/P_{pref} minus $F/P_{non\text{-}pref}$] ($p < 0.01$, FWE cluster corrected). The reverse contrast as well as similar contrasts for brain responses obtained for unfamiliar politicians did not yield significant results ($p < 0.001$, uncorrected, $k > 10$ voxels). R indicates right hemisphere. **B.** Average brain responses in the bilateral insula [F/P_B minus F/P_A] were positively correlated with preference scores of voluntary donations to parties [€(P_B) minus €(P_A)] across participants (Pearson's $r = 0.63$, $p < 0.05$). Positive values of donation scores indicated that P_B was favored over P_A while negative values pointed to a more favorable reaction towards P_A compared to P_B. **C.** Significant positive correlation was also found for mean responses in the cingulate cortex and differences in voluntary donations to parties (Pearson's $r = 0.51$, $p < 0.05$, one tailed). The p-values for ROI-based analyses are Bonferroni corrected to account for multiple comparisons.

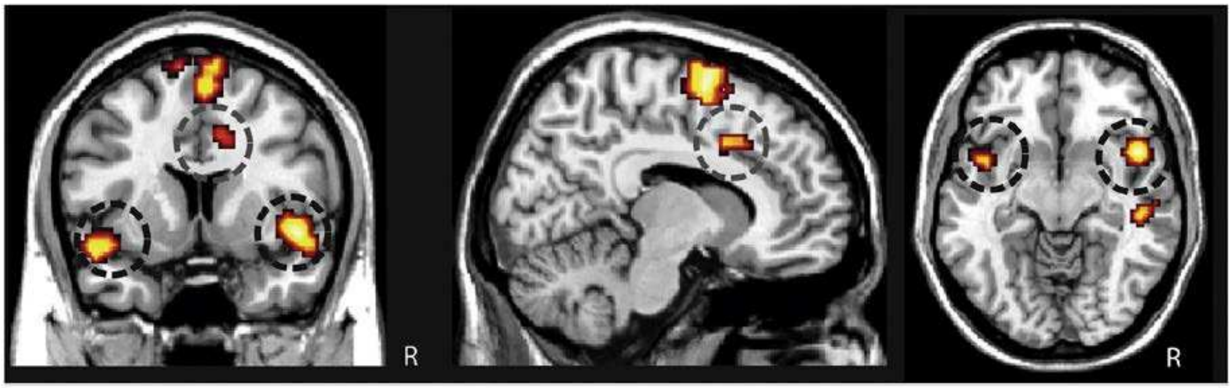

Figure 4. Brain regions encoding party preference independent of individual preference judgments for politicians.

Results of an additional control analysis provide further evidence that activity in the bilateral insula and the cingulate cortex reflect party preference independent of politician-specific processing. Here, we implemented a GLM that contained parametric regressors for self-reported party preference that were orthogonalized with respect to preference judgments for politicians. Group analysis on these individual parametric regressors for party preferenceconfirmed that activation in the cingulate cortex (peak at [MNI 12, 11, -17], $t = 4.09$; encircled in grey) and the bilateral insula (peaks at [MNI 45, 11 -8], $t = 4.65$ and [MNI -48, 11, -17], $t = 4.09$; encircled in black) reflected party preference independent of politician-specific valuation (simple t-test; for illustration purposes displayed at $p < 0.005$, $k > 20$ voxels). The clusters are consistent with the ones reported above for the main analysis. R illustrates the right hemisphere.

Table 1: Brain areas that correlate withindividual preference ranks for familiar politicians obtained after scanning

Brain region	Side	BA	k	T	MNI		
					x	y	z
Dorsolateral prefrontal cortex	R	9	136	6.28	51	5	31
Supplemental motor area extending to dACC	L/R	6/24	774	8.06	12	-7	64
Ventral striatum (caudate)	L/R		105	5.52	-6	14	4
Posterior superior temporal gyrus	R	22	106	5.87	57	-43	16
Fusiform gyrus	R	37	448	10.47	33	-49	-11
	L	37	546	8.61	-30	-64	-8
Occipital cortex	L	19	272	6.36	-30	-79	13
Precuneus/occipital cortex	R	7/19	124	5.80	24	-73	34
Midbrain/cerebellum	L/R		319	7.86	0	-31	-8

P < 0.01, FWE cluster corrected, only peak activations of clusters are reported; dACC = dorsal anterior cingulate cortex; L = left hemisphere, R = right hemisphere, BA = Brodmann area, MNI = Montreal Neurological Institute, k = cluster size.

Table 2: Brain areasthat reflected self-reported party preference obtained after scanning

Brain region	Side	BA	k	T	MNI		
					x	y	z
Cingulate cortex/medial prefrontal cortex	L/R	23/24/32/10	759	5.48	-3	17	22
Insula	R		209	5.41	57	11	-14
Insula extending to superior temporal gyrus	L	22	683	5.49	-42	2	-17
Superior temporal gyrus	R	22	139	4.52	60	-19	-5

$P < 0.01$, FWE cluster corrected, only peak activations of clusters are reported; L = left hemisphere, R = right hemisphere, BA = Brodmann area, MNI = Montreal Neurological Institute, k = cluster size.